

Physics II

030

16 / 11 / 2015 8.30 am – 11.30 am



ADVANCED LEVEL NATIONAL EXAMINATIONS, 2015

SUBJECT: PHYSICS

PAPER II: THEORY

| | | |
|--------------|--|-------|
| COMBINATIONS | PHYSICS-CHEMISTRY-MATHEMATICS | (PCM) |
| | MATHEMATICS- PHYSICS- COMPUTER SCIENCE | (MPC) |
| | PHYSICS –CHEMISTRY- BIOLOGY | (PCB) |
| | MATHEMATICS –PHYSICS- GEOGRAPHY | (MPG) |
| | PHYSICS-ECONOMICS-MATHEMATICS | (PEM) |

DURATION: 3 HOURS

INSTRUCTIONS:

- 1) Do not open this paper until you are told to do so.
- 2) This paper consists of **two** sections **A** and **B**.
Section A: Attempt **all** questions. (55 marks)
Section B: Attempt **only three** questions. (45 marks)
- 3) Non- programmable scientific calculators and mathematical sets may be used.
- 4) **Useful constants:**

| | |
|----------------------------------|--|
| Acceleration due to gravity: | $g = 9.81 \text{ m/s}^2$ |
| Molar gas constant: | $R = 8.314 \text{ J/mol K}$ |
| Specific heat capacity of water: | $C_e = 4\,200 \text{ J/kg K}$ |
| Permeability of free space: | $\mu_0 = 4 \pi \times 10^{-7} \text{ Hm}^{-1}$ |
| Planck's constant: | $h = 6.63 \times 10^{-34} \text{ Js}$ |
| Speed of light in vacuum/air: | $C = 3 \times 10^8 \text{ m/s}$ |
- 5) Use blue or black pen only.

SECTION A: ATTEMPT ALL QUESTIONS. (55 MARKS)

- 1) The distance S in metres travelled by a particle is related to the time t in seconds by the equation of motion $S = 10t + 4t^2$.

(a) What is the initial position of the particle?

(1mark)

(b) Determine its initial velocity.

(1mark)

(c) Find the acceleration of this particle.

(1mark)

- 2) (a) Figure 1 shows two parallel charged, conducting plates.

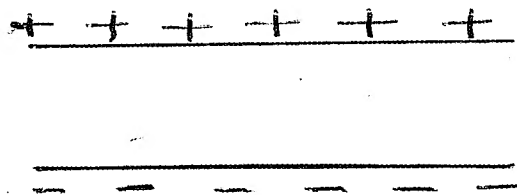


Figure 1

Copy the figure and add lines to show the direction of the electric field in the space between them.

(1mark)

(b) Mention any two factors on which the capacitance of a parallel plate capacitor depends.

(2marks)

- 3) (a) Why is the sun sometimes termed the primary renewable energy source?

Support your answer with the aid of two real examples.

(2marks)

(b) Explain briefly how solar cell (photovoltaic cell) works.

(2marks)

- 4) Distinguish cathode rays from X rays basing on their characteristics and how they are produced.

(4marks)

- 5) (a) What change would you observe in coil 2 connected to a galvanometer G when you vary the current in coil 1 (the switch K is open and closed alternatively)(figure 2) and what do you conclude?

(2marks)

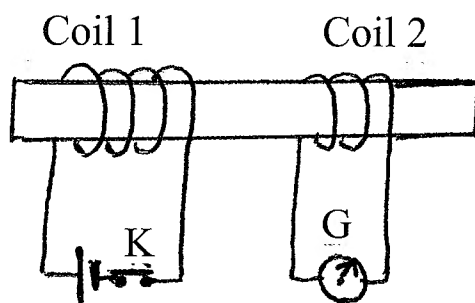


Figure 2

(b) What is the energy stored in an inductor of 10 H with a current of 5 A?

(2marks)

- 6) (a) A horizontal bimetal plate consists of two materials of different coefficients of thermal expansion (figure 3). The coefficient of thermal expansion of the top part of the plate is greater than the coefficient of thermal expansion of the bottom part.

If the temperature of the entire plate increases, what happens to the plate?

(1mark)

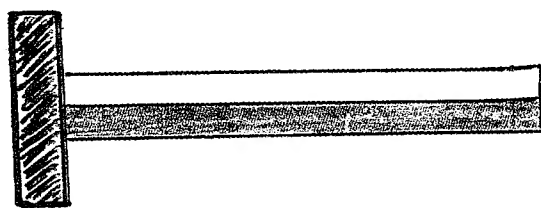


Figure 3

(b) A piece of copper is dropped into a beaker of water.

If the temperature of the water rises, what happens to the temperature of the copper?

(1mark)

(c) Calculate the amount of heat absorbed by 200 grams of water when it is heated from 30°C to 40°C.

(2marks)

7. (a)(i) Under what circumstances will there be no refraction of light when it enters from one medium to another with different refractive indices?

(1mark)

(ii) Figure 4 shows the refraction of a ray of light by a rectangular glass block. Use the given angle to determine the angle of emergence (angle a in figure 4)

(1mark)

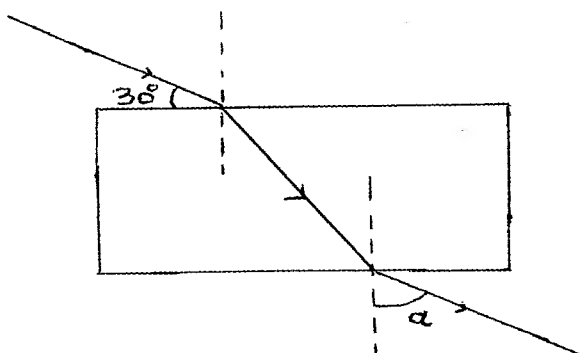


Figure 4

(b) A ray of light is incident at 60° at air –water plane surface and the refractive indices of water and air are $\frac{4}{3}$ and 1 respectively. Calculate the angle of refraction in the water.

(2marks)

8. (a) With the aid of two elements, describe the image formed by a plane mirror.

(1mark)

(b)(i) A 4.0 cm tall object is placed at 20 cm in front of a convex mirror that has a focal length of -20 cm.

Calculate the image position.

(2 marks)

(ii) State any one property of this image.

(1 mark)

9. (a) Provide any one way to demagnetize a ferromagnetic material.

(1mark)

(b) A positive charge q moving with a constant velocity \vec{v} enters

a region of a uniform magnetic field \vec{B} in the direction indicated by the arrows as shown in figure 5. Write down the expression of the magnetic force on the charge and indicate its direction. **(2marks)**

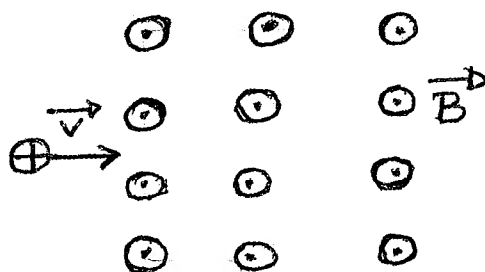


Figure 5

- 10) A vertical conductor Y carries an upward current of 5 A.
- Draw the patterns of magnetic flux in a horizontal plane round Y and indicate the direction of the magnetic field at a chosen point. **(1mark)**
 - What is the magnitude of the magnetic field due to the current alone at point Q located at 5 cm from Y? **(2marks)**
- 11) (a) The resistance of a resistor is doubled by changing it from $5\ \Omega$ to $10\ \Omega$. What happens to the current flowing through the circuit if the potential difference across this circuit remains constant? **(1mark)**
- (b) (i) A voltmeter is connected to the terminals of a battery that has electromotive force of 12 V and internal resistance of $3\ \Omega$; the battery is not connected to any other external circuit elements. What is the reading of the voltmeter? **(1 mark)**
- (ii) The voltmeter is now removed and a $21\ \Omega$ resistor is connected to the terminals of the battery. What is the current through the battery? **(2marks)**
- 12) (a)(i) What is the role of non zero net torque in rotational motion? **(1mark)**
- (ii) Describe the law of conservation of angular momentum. **(1mark)**
- (b) A mass of 0.8 kg at the end of a rope 0.5 m long is whirled round in a horizontal circle at an angular speed of 10 rad/s. What is its angular momentum about the centre? **(2marks)**
- 13) A component is connected across the terminals of a signal generator which supplies an alternating current output at constant voltage. If the frequency of this alternating current output is doubled, state with proof the effect on the current flowing through the component if it is a
- Pure inductor. **(2marks)**
 - Pure capacitor. **(2marks)**
- 14) A sphere ball is dropped without initial velocity into a falling ball viscometer containing a viscous fluid and falls under gravity. Use Stokes' law and physical grounds related to the steady flow of a fluid to answer the following questions.
- Name any one force which acts on this falling ball. **(1mark)**

- (b) Which force is greater at the beginning of a falling sphere's drop? **(1mark)**
 (c) As a sphere falls, which force increases? **(1mark)**

- 15) (a) A block of mass 2.0 kg is being pulled on a horizontal bench by a force of 12 N. If the block accelerates at 5.0 m/s^2 , what is the frictional force between the block and the bench? **(2marks)**
 (b) A car is moving along a straight road at a speed of 108 km/h, by applying breaks, it is brought to rest within a distance of 250 m. Calculate the retardation (deceleration) of the car. **(2marks)**

SECTION B: ANSWER ANY THREE QUESTIONS. (45 MARKS)

- 16) (a) A person wants to use a convex lens as a simple magnifying lens. At what distance from the lens, must the object be placed and why? **(2 marks)**
 (b) The power of a magnifying lens is 2 dioptres. Determine its focal length. **(2 marks)**
 (c) An object 1 cm tall is placed 30 mm in front of a lens. An image of the object is located 60 mm behind the lens.
 (i) Is the lens converging or diverging? **(2 marks)**
 Explain your reasoning without calculations.
 (ii) What is the focal length of the lens? **(3 marks)**
 (iii) Copy the axis below drawn not to scale (figure 6) on a graph paper and draw the lens at the position $x = 0$. With the aid of three principal rays from the object, locate the image in order to verify the situation described above in 16(c). **(3 marks)**

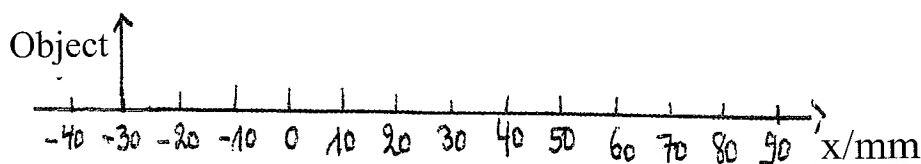


Figure 6

- (d) Based on your diagram in c (iii), describe the image by answering the following questions **(1 mark)**
 (i) Is the image real or virtual? **(1 mark)**
 (ii) Is the image smaller than, larger than or same size as the object? **(1 mark)**
 (iii) Is the image inverted or upright compared to the object? **(1 mark)**
- 17) (a) What is meant by the following terms : **(1 mark)**
 (i) Ductility ? **(1 mark)**
 (ii) Malleability ?

(iii) Elasticity ?

(1 mark)

(b) When a body of 2 kilograms is suspended from a spring, the spring stretches 4 cm. Find :

(i) The weight of this body.

(2 marks)

(ii) The force constant of the spring.

(2 marks)

(c) With reference to the appropriate physical principles, explain in terms of the kinetic theory of matter why gas exerts pressure on the walls of the container.

(2 marks)

(d) A steel rod 2 m long and 0.5 cm^2 in area stretches 0.24 cm under a tension of 12 000 N.

(i) Calculate the stress in the rod.

(2 marks)

(ii) Determine the strain in the rod.

(2 marks)

(iii) What is Young's modulus for the steel rod?

(2 marks)

18) (a) The equation of state of an ideal gas is $PV = nRT$.

For each of these symbols, state the physical quantity and SI unit. Use a table like the one below.

(5 marks)

| Symbol | Physical quantity | SI unit |
|--------|-------------------|---------|
| P | | |
| V | | |
| n | | |
| R | | |
| T | | |

(b) 0.80 moles of an ideal gas monatomic is enclosed in a cylinder by a frictionless, perfect-fitting piston. The conditions are such that the gas expands at constant pressure (process A B), it is then compressed at constant temperature (process B C) until its volume returns to the original value. These changes are represented together with the relevant numerical data on the graph in the figure 7.

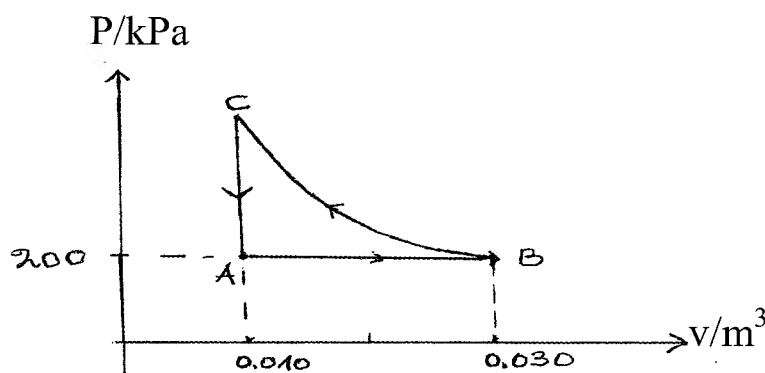


Figure 7

Analyse figure 7 above and answer the following questions

- (i) What is the pressure and the volume of the gas at point A? **(2 marks)**
- (ii) Which parts of the diagram correspond to isobaric and isochoric processes respectively? **(2 marks)**
- (iii) Show that the temperature of the gas at A is 301 K. **(2 marks)**
- (iv) What is the temperature of the gas at point B? **(2 marks)**
- (v) Calculate the pressure of the gas at point C. **(2 marks)**

- 19) (a) Figure 8 below shows the variation with time t of the displacement x of the cones of two identical loudspeakers A and B placed in air. Analyse the figure and answer the questions that follow.

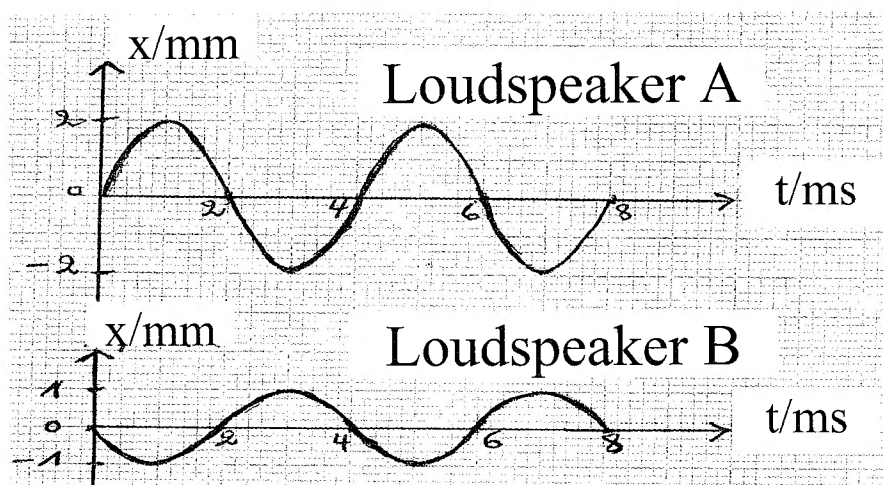


Figure 8

- (i) What is the period of vibration of the loudspeaker cones? **(1mark)**
 - (ii) Calculate the frequency of vibration of the loudspeaker cones **(2marks)**
 - (iii) Provide at least three elements of comparison between the vibrations of cones A and B. **(3marks)**
 - (iv) State the type of the wave produced in the air in front of each loudspeaker. **(1mark)**
 - (v) Suggest with a reason, which loudspeaker is likely to be producing the loudest sound. **(2marks)**
- (b) (i) An organ pipe, closed at one end, is excited so as to support the 3rd overtone(7th harmonic). How many nodes and antinodes are in the pipe? Use the diagram to support your answer. **(2marks)**
- (ii) Determine the length of an open-end air column required to produce a fundamental frequency(1st harmonic)of 480 Hz. The speed of sound in air is known to be 340 m/s **(2 marks)**
- (c)A tuning fork of frequency 480 Hz produces 10 beats per second when sounded together with a vibrating sonometer wire. What is the frequency of this sonometer wire? **(2marks)**
- 20) (a) Differentiate between polarization and diffraction of light. **(2marks)**
- (b)(i)Explain the concept of particle-wave duality of light. **(2marks)**

(ii) Copy and complete carefully **each space** of the following table using **yes** or **no** where necessary.

(7marks)

| Phenomena | Can be explained in terms of waves | Can be explained in terms of particles |
|-----------------------|------------------------------------|--|
| Reflection of light | | |
| Refraction of light | | |
| Interference of light | | |
| Diffraction of light | | |
| Polarization of light | | |
| Photoelectric effect | | |
| Compton effect | | |

(c)(i) Write down an expression of the linear momentum and its SI units of a visible photon that has a wavelength λ . Remember that a photon doesn't have a rest mass.

(2marks)

(ii) Show that the energy of a photon is given by $E = PC$

(2marks)

Where P is the linear momentum of the photon, C is the speed of light in vacuum or in air.